national film board
of canada

For High School and Junior College

film loops for project physics

A series of forty-eight 8mm film loops
produced by the
National Film Board of Canada
in consultation with
physics teachers and specialists
and designed to change your classroom
into an active and effective physics lab.

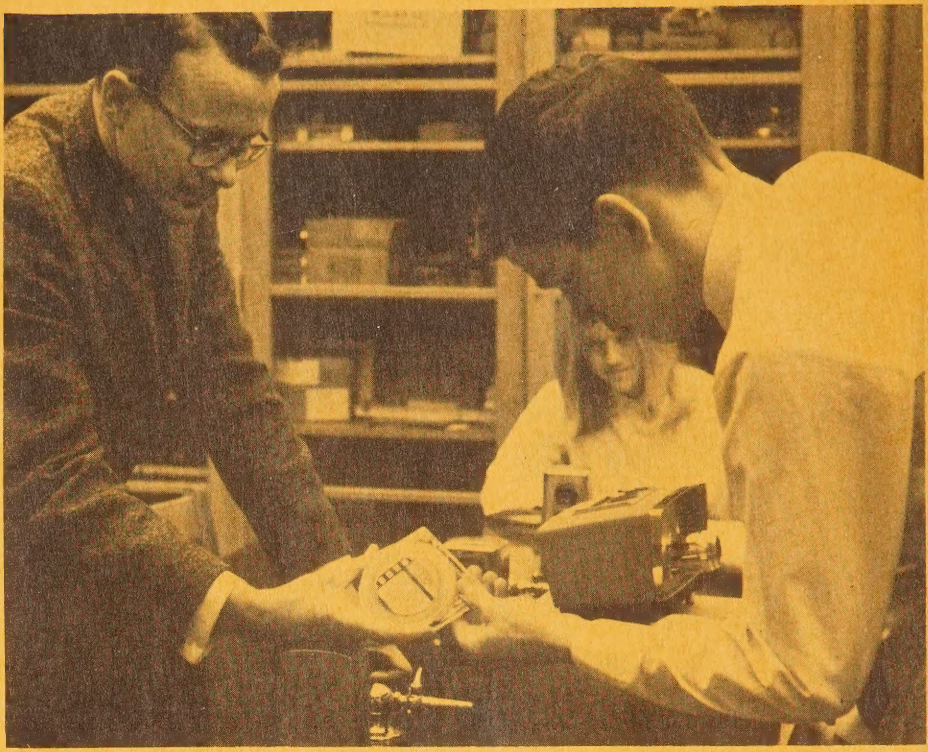
Film Loops for Project Physics

In 1964, NFB film-maker Jacques Parent and physics teacher Jacques Laberge conceived and developed techniques for the use of short film loops in the teaching of physics. Basic to their concept was the idea of presenting physical phenomena in a way that would enable the film loop to be used personally by the student in place of actual lab and field experiments. They produced sixteen physics film loops concerned chiefly with kinematics – the observation of speed, time, space and motion. The titles of these sixteen loops (Physics I Series) are listed in this brochure.

The present series of 48 Film Loops for Project Physics, produced by the National Film Board of Canada, is part of a comprehensive teaching system, known as Project Physics and developed in the United States at Harvard University. Among the architects of the program are: Dr. Gerald Holton, physicist and science historian; Dr. Fletcher G. Watson, astronomer and science teacher; and Dr. F. James Rutherford, scientist and former high school physics teacher. Contributors to the design of the film loops were such physicists and physics teachers as: Dr. Alfred Leitner, Rensselaer Polytechnic Institute; Dr. Franklin Miller, Kenyon College; Dr. Owen Gingerich, Harvard University; Dr. Alfred Bork, Reed College.

Assisting Messrs. Parent and Laberge at the National Film Board were: Maurice Bulbulian, Eric Chamberlain, Don Hopkins, Ernie McNabb, Jacques Vallée and Robert Yuile.

The forty-eight 8mm film loops in this new physics teaching program are each self-contained, self-storing, self-starting, in film cassettes. They just plug in or pull out of the film projector and can be used by any student or teacher with virtually no preliminary practice. Notes for each loop are in each cassette container, ready at hand whenever the loop is used. A comprehensive illustrated teacher's manual is also provided for the series.



For Any Physics Teaching Program

The 48 Film Loops for Project Physics provide a way to understand physics that involves the student actively in the discovery and utilization of knowledge. With these loops the teacher is enabled to do in his own classroom what hitherto may have been limited to the physics laboratory.

Testing and evaluation of these physics film loops in selected classrooms in Canada and the United States has shown that students and teachers both respond enthusiastically to this program for participation in discovery and comprehension of physics.

The Quebec Department of Education has chosen to base its new physics program on several units of the Film Loops for Project Physics. The loops have already been tried in ten Quebec school districts. Tests and evaluations conducted in schools in Montreal, Winnipeg and Vancouver show that with the physics film loops as much as 70 per cent of the knowledge is obtained by self-instruction and self-discovery. Students' use of conventional lab equipment is made with greater care and appreciation, and the teacher's place as resource leader is immediately improved. In many cases, students showed surprising initiative and enthusiasm for inventing their own auxiliary equipment for physics experiments.

The loops provide a novel and highly successful way for students to participate in experiments. They encourage him to take his own data from the demonstrations on the screen. An example is *Analysis of a Hurdle Race*, in which slow motion photography enables the students to make their own position measurements as the film proceeds. Since the loops repeat automatically, students trying this technique can easily correct or catch up on anything they miss the first time round. This provision for student participation encourages self-teaching and further lab work. Such "lab loops" are identified in this brochure by the initial "L" after the film description.

The National Film Board of Canada gratefully acknowledges assistance and advice from the following teachers (and their schools), who tested these materials from time to time in their own classrooms:
John Jared, John Rennie High School
Pointe Claire, Quebec
Yvon Lapointe, Two Mountains High School
St. Eustache, Quebec
Ron MacQueen, West Vancouver
Secondary School, British Columbia
Fred M. Olsen, St. Johns Ravenscourt School
Winnipeg, Manitoba

Supplementary Materials
Film Loops for Project Physics

Notes for each loop are provided in each box.

A teacher's manual, printed and illustrated, is provided with each series of the 48 Film Loops for Project Physics. Additional copies of this manual may be purchased.

Two Flat Picture Sets, related to some of the loops, are available for purchase. These are sets of study prints, each consisting of seven black-and-white pictures, 8" x 11", entitled *One-dimensional Collisions* and *Two-dimensional Collisions*. The study prints are stroboscopic photographs from which students can make measurements. Accompanying text provides the students with guidance for the activities. Additional notes are provided for teachers' use.

A 16mm sound film, in color, is available for purchase. It demonstrates how the physics film loops can transform an ordinary classroom into an active, enthusiastic physics lab.

Physics I Series

This original series of sixteen physics film loops is concerned chiefly with kinematics – the observation of speed, time, space, motion.

Notes for each loop are provided in each box.

A workbook is provided for the student, so that his practice is related directly to what he has seen. Together, films and workbook constitute a practical classroom lab and encourage independent experiment, observation and calculation.

Following are the titles of the sixteen loops:

0165746
The Idea of Speed: I

0165747
The Idea of Speed: II

0165748
The Idea of Speed: III

0165749
Instantaneous Speed: I

0165750
Instantaneous Speed: II

0165751
Instantaneous Speed: III

0165752
Average Speed

0165753
Measurement of Very High Speed

0165754
Types of Motion

0165755
Uniform Motion in a Straight Line

0165756
Motion with Uniform Acceleration

0165757
Free Fall

0165758
Displacement

0165759
Measurement of Time: I

0165760
Measurement of Time: II

0165761
Measurement of Time: III

Purchase Prices

The Film Loops for Project Physics Series and the Physics I Series may be bought as individual loops, by units, or as complete series. Purchase prices for each 8mm loop are as follows:

Super 8mm cassette-loaded:
$21.50 (List price)
$17.00 (Canadian Educational price)

Standard 8mm cassette-loaded:
$18.50 (List price)
$14.00 (Canadian Educational price)

Super 8mm on 50-foot reel:
$20.00 (List price)
$16.00 (Canadian Educational price)

Physics film loops are also available in 16mm gauge, for those who have need of them for special uses such as workshops, at $25.00 (List price), $17.00 (Canadian Educational price).

Prices for the Flat Picture Sets and for additional study prints may be obtained on request.

Additional copies of the teachers' manual for the Film Loops for Project Physics cost $1.25 each.

Additional copies of the workbook for the Physics I Series cost $1.00 each.

The above prices include transportation by surface route, and are subject to change without notice.

Purchase orders should be addressed to:
Canadian Division
National Film Board of Canada
P.O. Box 6100
Montreal 3, Quebec

Printed in Canada 0167220

Film Loops for Project Physics Series

Note: (L) indicates "lab loops" from which students can take direct measurements.

about Concepts of Motion

These nine film loops introduce some concepts of motion, free fall, some complex motions, and an introduction to dynamics. They actively involve the student in measuring speeds and calculating accelerations. Slow-motion photography is used to bring objects in free fall and ballistic trajectory into the student's own time frame.

0167720
Acceleration Due to Gravity: I
Slow-motion photography in one continuous sequence allows measurements of the average speed of a falling bowling ball during two 50-cm intervals separated by 1.5 m. (L)

0167721
Acceleration Due to Gravity: II
Slow-motion photography allows measurement of the average speed of a falling bowling ball as it passes through four 20-cm intervals spaced 1 m apart. (L)

0167722
Vector Addition: Velocity of a Boat
A motorboat is viewed from above as it moves upstream, downstream, across stream, and as it heads at an angle upstream. Vector triangles can be drawn for the various velocities involved. (L)

0167724
A Matter of Relative Motion
A collision between two equally massive carts is viewed from various stationary and moving frames of reference.

0167725
Galilean Relativity:
Ball Dropped from Mast of Ship
A realization of the experiment suggested in Galileo's Two New Sciences: the ball lands at the base of the mast of the moving ship.

0167726
Galilean Relativity:
Object Dropped from Aircraft
A flare is dropped from an aircraft that is flying horizontally. The parabolic path of the flare is shown, and freeze frames are provided for measurement of the position at ten equally spaced intervals. (L)

0167727
Galilean Relativity:
Projectile Fired Vertically
A flare is fired vertically from a Ski-doo that is moving along a snow-covered path. Events are shown in which the Ski-doo's speed remains constant, and also when its speed changes after firing.

0167728
Analysis of a Hurdle Race: I
Slow-motion photography allows measurement of speed variations during a hurdle race. (L)

0167729
Analysis of a Hurdle Race: II
A continuation of the preceding loop. (L)

about Motion in the Heavens

These eight film loops deal with the dynamics of our planetary system. The films put our understanding of these motions in historical context by illustrating rival theories for retrograde motion. Both physical models and computer animation are used in these films.

0167730
Retrograde Motion:
Geocentric Model
A machine was constructed in which the planet is represented by a lamp bulb on an epicyclic arm revolving around a deferent; the camera is at the position of the stationary earth, pointing in a fixed direction in space.

0167731
Retrograde Motion:
Heliocentric Model
The epicycle machine is used with the camera on an arm revolving around the sun; the camera points in a fixed direction in space.

0167732
Jupiter Satellite Orbit
Time-lapse photography, at one-minute intervals, of the motion of Jupiter's satellite, Io. The period of revolution can be measured, the scale is given, and hence Jupiter's mass found. (L)

0167733
Program Orbit: I
A computer is programmed to calculate the same orbit that a student calculates in the laboratory; the result is displayed on an X-Y plotter. Because of the step-wise approximation used, the orbit fails to close up exactly.

0167734
Program Orbit: II
The computer calculates an orbit using many more points than in the preceding loop; this time the orbit closes up. The display on the X-Y plotter is repeated on the face of a cathode-ray tube (CRT). (All other computer loops in this series use CRT display.)

0167735
Central Forces: Iterated Blows
The computer is programmed to give sharp blows to a mass at equal time intervals. The blows are directed (at random) toward and away from a center of force; the magnitude of the blows is also random. The Law of Areas can be verified.

0167736
Kepler's Laws
Two planetary orbits in an inverse-square force field are programmed for display on the CRT; the positions of the planets are shown at successive equally spaced time intervals. All three of Kepler's laws can be verified. (L)

0167737
Unusual Orbits
The computer is programmed to display two motions that take place in central fields but which are not exact inverse-square fields. One perturbation gives an advance of perihelion, as for Mercury's orbit; the other perturbation gives a catastrophic orbit in which the planet spirals into the sun.

about Energy

These 26 film loops introduce the laws of conservation of mass and momentum, mechanical energy, the first law of thermodynamics, kinetic theory, and mechanical waves. A number of corollary themes are touched on, including spatial and temporal symmetry and the connection between science and technology.

0167738
One-dimensional Collisions: I
Slow-motion photography of elastic one-dimensional collisions. (L)

0167739
One-dimensional Collisions: II
A continuation of the preceding loop, showing different events. (L)

0167740
Inelastic One-dimensional Collisions
Slow-motion photography of inelastic one-dimensional collisions. (L)

0167741
Two-dimensional Collisions: I
Slow-motion photography of elastic collisions in which components of momentum along each axis can be measured. (L)

0167742
Two-dimensional Collisions: II
A continuation of the preceding loop, showing different events. (L)

0167743
Inelastic Two-dimensional Collisions
A continuation of the preceding two loops, showing inelastic two-dimensional collisions; plasticene is wrapped around one ball. (L)

Note:
Flat Picture Sets dealing with one-dimensional and two-dimensional collisions are also available, and are described in this brochure under Supplementary Materials.

0167744
Scattering of a Cluster of Objects
In slow-motion photography, a moving ball collides with a stationary cluster of six balls of various masses. Momentum is conserved. (L)

0167745
Explosion of a Cluster of Objects
A powder charge is exploded at the center of a cluster of five balls of various masses. One ball is temporarily hidden in the smoke; the position and velocity of its emergence can be predicted, using the law of conservation of momentum. (L)

0167746
Finding the Speed of a Rifle Bullet: I
A bullet is fired into a block of wood suspended by strings. The speed of the block is measured directly by timing its motion in slow-motion photography. (L)

0167747
Finding the Speed of a Rifle Bullet: II
A bullet is fired into a block of wood suspended by strings. The speed of the block is found by measuring its vertical rise. (L)

0167748
Recoil
A bullet is fired from a small model gun. Direct measurements can be made of the bullet's speed and the speed of recoil of the gun. (L)

0167749
Colliding Freight Cars
The collision of two freight cars is photographed in slow-motion during a railroad test of the strength of couplings. (L)

0167750
Dynamics of a Billiard Ball
Slow-motion photography of a rolling ball striking a stationary ball. The target ball slides, then starts to roll. Linear momentum and angular momentum are conserved. (L)

0167751
A Method of Measuring Energy: Nails Driven into Wood
A nail is driven into wood by repeated identical blows of a falling weight. A graph of penetration depth versus number of blows can be made; the result is nearly a straight line. This loop establishes a criterion for energy measurement used in the next two loops. (L)

0167752
Gravitational Potential Energy
Dependence of gravitational potential energy on weight; dependence on height. (L)

)167753
Kinetic Energy
Dependence of kinetic energy on speed; dependence on mass. Slow-motion photog-raphy allows direct measurement of speed. L)

)167754
Conservation of Energy: Pole Vault
The total energy of a pole vaulter can be neasured at three times: just before takeoff, he energy is kinetic; during the rise it is artly kinetic, partly gravitational potential, nd partly elastic energy of the distorted ole; at the top, it is gravitational potential nergy. (L)

)167755
Conservation of Energy: Aircraft Takeoff
lying with constant power, an aircraft moves orizontally at ground level, rises and levels ff. Kinetic and potential energy can be neasured at three levels. (L)

167756
eversibility of Time
fter showing some real-life actions that may or may not) be reversible, the film shows vents of increasing complexity: a two-ball ollision on a billiard table; a four-ball event; nd finally, a ball rolling to a stop while aking some 10^{23} (invisible) collisions with e molecules of the table surface.

167757
uperposition
mplitudes and wavelengths of two waves re varied; the resultant is shown. Display is three colors on the face of a cathode-ray ibe.

0167758
Standing Waves on a String
Production of standing waves by interference of equal waves moving in opposite directions is shown in animation. Then a tuning fork sets a string into vibration; several modes are shown as the tension is adjusted. The string's motion is also shown stroboscopically.

0167759
Standing Waves in a Gas
A loudspeaker excites standing waves in a glass tube containing air. Nodes and antinodes are made visible in two ways: by the motion of cork dust, and by the cooling of a hot wire inside the tube.

0167761
Vibrations of a Rubber Hose
A long vertical hose is agitated by a variable-speed motor at one end. The frequency is adjusted to show a succession of modal patterns.

0167762
Vibrations of a Wire
A horizontal stiff wire is set into vibration; the driving force is supplied by the interaction of alternating current through the wire and a fixed magnetic field. Several modes of vibration are shown, both for a straight wire (antinode at free end) and for a circular wire (nodes equally spaced around the circumference). The patterns are shown in real time and also stroboscopically.

0167763
Vibrations of a Drum
A loudspeaker is placed beneath a horizontal rubber drum head. Several symmetric and antisymmetric modes are shown stroboscopically, in apparent slow-motion.

0167764
Vibrations of a Metal Plate
Vibration patterns are made visible by sprinkling white sand on a vibrating plate; sand collects at the nodal lines.

about Light and Electromagnetism

0167760
Standing Electromagnetic Waves
This loop treats electricity, magnetism, and light – the beginning of a new physics. A 435 megacycle/sec transmitter feeds an antenna at one end of a metallic trough. When a metallic reflector is positioned at the other end, a standing wave is formed. Many small lamp bulbs at the centers of tuned di-poles make the pattern visible. Polarization is shown. Finally, the standing waves in this and the earlier two standing-wave loops are displayed simultaneously to emphasize the existence of nodes as a fundamental property of any standing wave.

about the Atom

0167765
Production of Sodium by Electrolysis
Davy's classical experiment in which molten $NaOH$ is electrolyzed to form metallic sodium.

0167766
Thomson Model of the Atom
Small magnets floating on the surface of water are aligned into various patterns by a radial magnetic field. The apparatus, a model of a model, was first described by J. J. Thomson.

0167767
Rutherford Scattering
A computer-animated film, in which projectiles are fired toward a nucleus which exerts an inverse-square repulsive force.

about the Nucleus

0167768
Collisions with an Unknown Object
Elastic collisions between balls of appropriate relative masses illustrate Chadwick's discovery of the neutron. (L)